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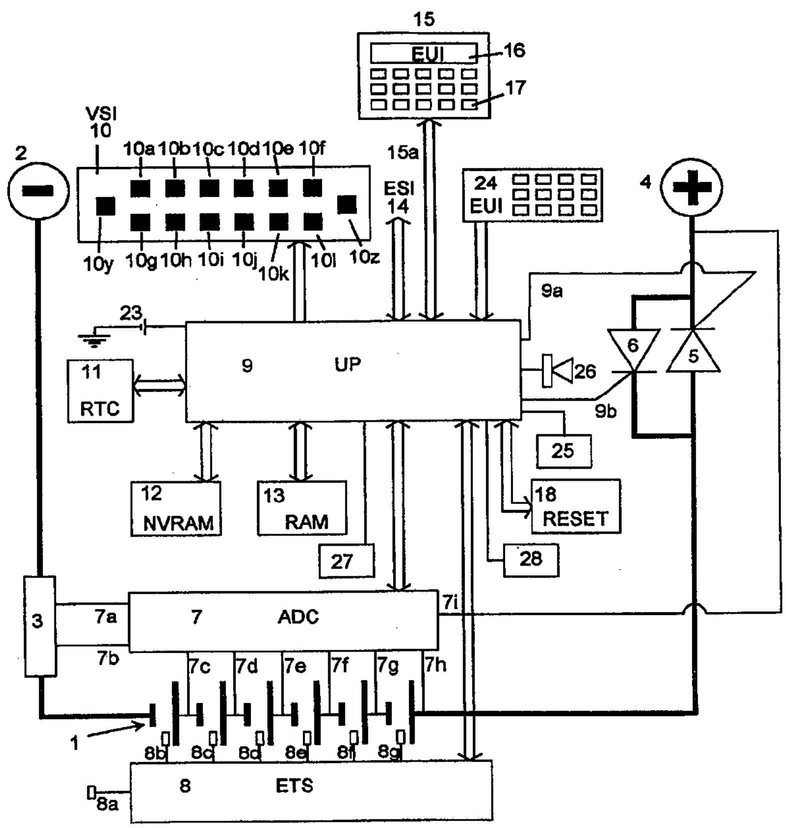
(54) Title: BATTERY AND BATTERY CONTROLLER

(57) Abstract

A controller (9, 5) for controlling the discharge and charging of a battery (1; 41) in dependence upon the load connected to the output terminals (2, 4; 45, 46) of the controller (9, 5). The controller may be integrated within a battery unit having a single battery (1) wherein discharge of the battery is controlled to ensure there is sufficient reserve capacity to start a vehicle. The controller (9, 5) may be integrated within a battery unit having two or more batteries (1, 20) in which one battery is normally used to start a vehicle and another battery is normally used to run other electrical loads. The controller (9, 5) may also be in the form of a unit (42) which may be secured to the terminals (43, 44) of a battery.



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BATTERY AND BATTERY CONTROLLER

The present invention relates to a battery and a controller for controlling the charging and/or discharging of a battery. More particularly, but not exclusively, the invention relates to a controller that monitors the state of charge of a battery and limits discharge of the battery when its state of charge falls below a predetermined level.

The controller may be formed integrally within a battery or may be coupled to a battery or may be part of the electrical control system of a vehicle and located remotely from the battery. Preferably the controller is incorporated into a standard two pole battery of standard dimensions. The controller may be used with single, dual or plural battery technologies.

It is common for an automobile battery to be left in a discharging state when a load, such as headlights, is accidentally left on. If unnoticed the battery may discharge to such a level that there is insufficient charge to crank the engine to restart the automobile. Further, the battery may be discharged to such a level that the battery plates are damaged and the life of the battery is reduced.

Three terminal plural batteries have been proposed as a solution to this problem. The battery consists of a first battery suited for cranking a vehicle engine and a second battery suited to supply the demands of the other electrical loads. The batteries have a common ground terminal and separate live terminals. The first battery is connected to supply the starter motor, starter solenoid and other loads required to effect starting of the engine. The second battery is connected to the remaining loads.

This arrangement has the advantage that if the lights or other remaining loads are inadvertently left on, only the second battery is discharged and the first battery is available to start the engine. This arrangement does, however, have the disadvantage that complex installation is required and the battery cannot simply replace an existing battery.

GB 2222494 discloses a battery incorporating circuitry which controls charging and discharging of the battery. The ground terminal of the battery is directly connected to a ground terminal of the control circuit mounted on top of the battery. A further terminal of the control circuit is directly connected to the positive terminal of the battery. Two further auxiliary terminals are provided on the control circuit, one of which ceases to supply power when the battery reaches 70% of full capacity, the other ceasing to supply power when the battery reaches 30% of full capacity. This is a multi terminal battery designed for yachts which could not be directly substituted for a battery in an automobile without rewiring. The controller circuit only ceases power supply of auxiliary terminals on the basis of the state of charge of the battery and takes no account of the load connected to any terminal.

US 5296997 discloses a protection system that may be installed in the electrical system of a vehicle between the battery and electrical loads of a vehicle. The system disconnects the supply of power to the loads when the battery voltage falls below a predetermined threshold. The battery is not reconnected to the loads until it is detected that the load connected to the battery is of a magnitude indicative that an attempt has been made to start a vehicle. The system requires the protection system to be installed within the electrical system of a vehicle which may be time consuming and expensive. As the system simply monitors battery voltage, the state of charge of the battery is not determined with any particular accuracy and, in some instances,

may leave insufficient charge in the battery to start a vehicle. Further, the threshold at which electrical supply is disconnected is not adjusted with battery ageing.

It is an object of the present invention to provide a controller which will prevent the discharge of a battery below a predetermined level or to at least provide the public with a useful choice.

Accordingly there is provided a controller for controlling the discharge of a battery via terminals which are connected, in use, to an electrical load, wherein the controller controls the rate of discharge of the battery via the terminals in dependence upon the state of charge of the battery and the load connected to the terminals.

The controller preferably monitors the charging and discharge of the battery and calculates the state of charge and reserve capacity based upon these measurements. Preferably the voltage across each cell of a battery, the voltage across the battery output terminals, the current flow in or out and the temperature of each cell are monitored.

The controller learns the power demand profiles of each load over time. The controller can learn the power sequence at start up (i.e. Door light on, accessories on, ignition coil connected, solenoid and starter motor). The controller can monitor the amount of power required to start the engine and set the threshold level accordingly. Further, the controller can recognise the type of load connected to the battery by comparing a periodically sensed load with the load profile stored in the controller. The controller may thus detect when a user is attempting to start the engine and connect the battery to the load even though the state of charge is below the threshold level. A manual override may be provided to allow a user to continue to draw power from the

battery until the battery is discharged to a level at which the cells of the battery would be damaged by further discharge.

If the load sequence at start up does not follow the sequence stored by the controller the controller may inhibit the supply of power from the battery to prevent theft. A movement detector may also be incorporated in the controller to inhibit the supply of power from the battery in the case of an accident or tampering with the vehicle.

Preferably the controller is incorporated within the battery so that the battery is of standard size and standard two terminal configuration. Alternatively the controller may be mounted on top of the battery or incorporated within the control circuitry of a vehicle.

The controller may include a real time clock so that the controller can monitor ageing of the battery and adjust its parameters accordingly. The controller may also use information from the real time clock to assist in learning a vehicles operating parameters (i.e. Lights are on at night).

The controller may include a visual user interface to display the state of the battery and each cell. This may be a LED or LCD display on the battery or a display within the cabin of a vehicle. An interface for servicing of the battery may also be provided. The controller may be a separate unit secured to a battery or integrally formed with a battery.

There is also provided a battery unit having first and second terminals, first and second batteries and a controller for selectively connecting the terminals of the first and second batteries to the first and second terminals.

The invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1: Shows a block diagram of a controller and battery for a single battery configuration;

Figure 2: Shows a block diagram of a controller and two batteries for a dual battery configuration ;

Figure 3: Shows the external appearance of a battery incorporating a controller according to figure 1.

Figure 4: Shows the battery of figure 3 with the top cover removed

Figure 5: Shows the battery of figure 4 with the controller unit removed.

Figure 6: Shows an alternative arrangement in which the controller is mounted to a side of the battery.

Figure 7: Shows an alternative arrangement in which the controller is mounted to an end of the battery.

Figure 8: Shows an embodiment in which the controller is a separate unit secured to a standard battery.

Figure 9: Shows a block diagram of the controller shown in figure 8.

In the embodiments of figures 1 to 7 the controller is located within the battery casing. In other embodiments the controller may be in the form of a unit which may be electrically connected to the terminals of a battery having terminals for connection from the controller to the electrical system of a vehicle. Alternatively the controller may be incorporated within the electrical control system of a vehicle remote from the battery. Although the operation of the controller is described with reference to use in an automobile it is to be appreciated that the controller may be used in a wide variety of applications.

Figure 1 shows a controller integrated with a standard six plate battery 1, as commonly used in automobiles. The negative terminal of the battery 1 is

connected to the negative terminal 2 via load sensing element 3. The positive terminal of battery 1 is connected to positive terminal 4 via SCRs 5 and 6. The voltage across each cell of battery 1, the voltage across load sensing element 3 and the voltage at positive terminal 4 are monitored by analogue to digital converter (ADC) 7 via lines 7a to 7i. Voltage information from ADC 7 is supplied in digital form to microprocessor 9. The temperature of each cell of battery 1 and the environmental temperature are measured by temperature sensors 8a to 8g and supplied in digital form to microprocessor 9 by temperature sensing means 8.

It will be appreciated that any desired battery configuration may be used including series connected batteries (such as 6 series connected 2 volt batteries). A series connected battery configuration has the advantage that individual cells may be replaced when necessary. The battery may provide an output voltage higher than the voltage to be supplied to the system (e.g. a 14 volt battery supplying a 12 volt system). By switching SCR 5 on and off a desired output voltage from the controller may be supplied.

Microprocessor 9 supplies drive signals to SCR 6 and SCR 5 via lines 9b and 9a to control the charging and discharge of battery 1. The charge SCR 6 may be rated at a lower value as it need only be rated to carry a charging current. The status of battery 1 may be displayed by LED display 10 which may be mounted on top of the battery casing. The central 6 by 2 LEDs 10a to 10m may be red/green LEDs that display the condition of respective cells of battery 1. LEDs 10y and 10z at either end of the display show the overall status of battery 1. It will be appreciated that the LEDs can be arranged in any desired manner - such as a line of LEDs. As the LEDs have a number of possible states (green on, green flashing, red on, red flashing, both off) a number of battery states may be displayed (e.g.: two green LEDs indicates a good cell, two red indicate a bad cell, two green LEDs at either end indicate good

overall condition of the battery, two red LEDs indicates bad condition, two flashing red LEDs indicates recharging is required etc.) It will be appreciated that the LEDs may be replaced by lamps etc as desired.

The display may also indicate the ageing of the battery (thus reduction of storage reserve capacity), the reserve capacity under current load conditions, the charging time to reach maximum reserve capacity, the remaining time before the load is shut off at the current rate of discharge, the individual cell voltages and overall battery voltage during charging and discharge and the individual cell temperatures during charging and discharging. The display may be utilised to service the battery based upon the status information displayed. It will be appreciated that other display technologies may be employed, such as an LCD display (in which case alphanumeric information may be displayed). A membrane keypad 24 may be provided to enable a user to selectively display desired information.

A real time clock (RTC) 11 supplies time information to microprocessor 9. Non-volatile memory 12 stores system parameters and information regarding battery condition. Microprocessor 9 can read and write to memory 12. This may be Flash, EERAM or battery backed RAM. Random access memory 13 provides short term memory for microprocessor 9.

Normally the controller will be powered by battery 1. When the controller is removed from battery 1 it is desirable that real time clock 11 and microprocessor 9 continue to operate. In this way time information is not lost and the microprocessor can sense when it has been reconnected to a battery and initiate itself. Real time clock 11 and battery 23 may be integrated into a single button type battery package.

Power management means 18 performs reset, monitoring and watchdog functions. This regulates the power up of the controller at manufacture and controlled shut down to sleep mode during periods of shelf storage or no service or during shut down to prevent over-discharge. The power management means may be integrated in microprocessor 9 or be a separate circuit.

Port 14 enables an external device to be connected to analyse information stored in the controller. This may be via an optical or RF link to avoid the need for electrical contacts within the battery environment. An optional remote external user interface 15 connected to port 15a provides status information within the cabin of a vehicle, as may be required in emergency vehicles for example. Information may be displayed on LCD 16 in response to user commands entered on membrane keypad 17. Information such as statistics on charging, discharging, individual cell performance, current reserve capacity and the percentage of operational efficiency and service life remaining may be displayed. An alarm may also be sounded to warn of imminent battery shut down to allow the user to override shut down or take corrective action. Interface 15 is preferably connected to the controller via an optical or RF link. Another way of displaying information within the cabin would be to provide a unit which plugs into a cigarette lighter and communicates with the system via modulated signals on the power supply lines.

During manufacture, load profiles for a particular vehicle and environment may be loaded into non-volatile RAM 12. Such load profiles will indicate typical currents drawn by loads such as the starter motor, starter solenoid, lights etc. Alternatively a general profile for a particular environment may be loaded and the controller may learn the load demands and sequences during normal operation. The controller will know the likely ranges of certain loads such as the cranking load, headlights and accessories. It will also know that

certain events occur in certain sequences (e.g. a small load precedes the cranking load in the cranking sequence) and certain events occur at certain times (e.g. headlights on at night). The controller can thus build up a profile of the load demands of the vehicle during use and store this profile in non-volatile memory 12.

The measurement of current flow into battery 1 may be measured in a number of ways. ADC 7 may measure the voltage across load sensing means 3 (a calibrated bar/shunt). ADC 7 also measures the voltage at terminal 4 relative to the voltage measured at line 7h so that the direction of current flow may also be determined.

Alternatively the voltage drop measured by ADC 7 across SCRs 5 and 6 may be load characterised to measure current flow and direction. In a further alternative the voltage drop across each cell of battery 1 may be monitored by ADC 7 and, from calibration and historical analysis of voltage drop under discharge and voltage rise under charging, the rates of charge and discharge of the battery could be calculated to acceptable accuracy. The calculation algorithm employed must compensate for deterioration of the battery plates due to ageing.

Profiles of battery characteristics are preferably stored in non-volatile RAM 12 at manufacture to enable the age related deterioration of the maximum reserve capacity and remaining service life to be calculated at any time. Such profiles may indicate the reserve capacity of a battery given measured parameters (e.g. cell voltage and temperature) given the ageing of a battery from monitoring charge/discharge of the battery. By measuring the voltage rise against time for each cell during charging and taking into account current flow, the final cell voltage and the holding of cell voltage, the condition of individual cells can be monitored. Further information regarding each cell, such as reserve

capacity, may be obtained by monitoring voltage drop over time for each cell. By timing the charge versus discharge current flow over a number of cycles the reserve capacity of the battery may also be calculated.

Temperature sensing means 8 supplies data regarding the external temperature from sensor 8a and the temperature of each cell from sensors 8b to 8g so that temperature can be taken into account when microprocessor 9 calculates the reserve capacity or performs ageing calculations. The temperature of each cell under charge and discharge can also be used by microprocessor 9 to monitor cell condition and thus indicate premature failure.

Non-volatile memory 12 stores information relating to parameters of the battery from the time of manufacture and at intervals during the life of the battery. Information as to typical vehicle loads and load sequences may also be loaded at the time of manufacture or at installation (via port 14). Alternatively these may be learnt during use .

When a working charger is connected to the battery ADC 7 senses an increased voltage across the terminals and, if the battery is not fully charged, microprocessor 9 switches on the charging SCR 6. During charging the voltage across each cell of the battery and the temperature of each cell are monitored. The charging rate allowed by SCR 6 is adjusted to ensure the cells of the battery are not damaged. During charging, sensor 3 monitors the current flowing into the battery and real time clock 11 provides time information from which the microprocessor calculates the increased reserve capacity of the battery. Temperature sensors 8b to 8g provide information as to the temperature of each cell during charging which can be indicative of the condition of each cell. ADC 7 monitors the voltage across each cell which also indicates the condition of each cell. The system also monitors how well the battery is charging compared to previous cycles and how well individual

cells are accepting charge. This information is used by the system to calculate the ageing of the battery for use when calculating the reserve capacity.

During discharge of the battery, the terminal voltage and amount of current flowing out of the battery is monitored via sensor 3 and ADC 7 so the reduction in capacity of the battery may be calculated. Alternatively, the voltage drop across SCRs 5 and 6 may be load characterised or the voltage drop across each cell of battery 1 may be compared with historical data as for charging. The voltage across each cell is also monitored by ADC 7 so that the condition of each cell may be monitored. The capacity of the battery is normally not allowed to drop below a defined loss of service level (LOS) at which a vehicle engine cannot be cranked and at which further discharge may damage the battery. A threshold capacity level above this, called margin above loss (MAL), is calculated by the system at which the engine of the vehicle may still be started. This threshold (MAL) is dependent upon the ageing of the battery, environmental temperature and the load demands of the engine. The system constantly calculates ageing of the battery based on measurements of the cell voltages, temperatures and charge/discharge characteristics. The required capacity to start the engine will vary depending upon temperature and the state of the vehicle(i.e. time required to crank the engine). By relating starting timings to the real time clock and a stored historical database of starting performance the system can predict the capacity required to start the engine. The system will monitor the battery and engine over time and adjust the MAL threshold in accordance with battery and engine condition. The MAL threshold may be set at an historical average or so as to ensure that sufficient capacity remains to start the engine in the most adverse conditions (i.e. lowest temperature and longest cranking recorded within a given period).

When the system detects that the capacity of the battery has reached the MAL threshold (typically due to discharge when lights etc. are left on when the engine is not running) discharge SCR 5 is switched off. Microprocessor 9 then periodically (say every second) switches on SCR 5 for a brief period to monitor the load connected to the battery. If the load is unchanged SCR 5 switches off again. If the load is considerably greater than the previously monitored load and/or approximately equal to the known starter solenoid load then the system assumes an attempt is being made to start the engine and SCR 5 is left on to allow cranking of the engine. If a very high cranking current is not detected within a predetermined time frame it is assumed that the previous assumption was incorrect and SCR 5 is again shut off. The last detected load then becomes the new reference load to be used to determine if the starter solenoid has been switched on. If the load is significantly reduced it is assumed that the draining load has been switched off and SCR 5 will be switched on to resume power supply to the vehicle electrical system. The controller may be programmed to allow discharge at a low level to maintain certain electronic circuitry if desired.

Successful starting of the engine is detected by decreased load from the starter and an increase in voltage at terminal 4 due to the alternator/generator supplying power. At this point SCR 6 is turned on so that the battery can be charged. The system monitors the amount of charge flowing into the battery and in conjunction with real time clock 11 calculates the increased reserve capacity. The system also monitors how well the battery and each cell is charging compared to previous cycles.

If the system has been programmed to recognise particular loads or has learnt the loads of the system then the system can shut off supply from the battery when loads of a particular type have been running for a defined period under prescribed conditions (i.e. headlights on for an hour whilst the engine is off

etc.). An override function may be provided so that if the load is switched off and on again the battery will supply power for another defined period. Further, if the load is cycled on and off twice within a prescribed time frame the system may override this function completely and supply power until the MAL threshold is reached.

A motion detector 25 may also be included in the controller. This may be used to disable the battery if a shock indicating an accident is detected, thus reducing the risk of fuel ignition etc. This may also be used to indicate that a vehicle is being tampered with and disable the battery for a period.

A certain degree of security may also be obtained using the load monitoring function of the controller. The controller will learn that at starting there is a typical sequence of loads. Typically a small load for the interior light will be sensed first, followed by a small load for the dashboard lamps, followed by a larger load for the solenoid current followed by a very large cranking current. If this sequence is not followed the controller may assume that the vehicle is being interfered with and prevent the supply of power to the vehicle for a predetermined period. In the most minimal implementation the controller may be required to sense the solenoid current before the cranking current. Ideally, the entire starting current profile should be detected to enable starting. Further, users could define particular starting sequences required to enable the vehicle to start. For example, it may be required to turn the car headlights on and off to enable the controller to supply the starting current. Any particular load profile could be programmed as required.

There may also be provided an RF receiver 27 capable of providing information to microprocessor 9 received via an RF link. Pager/telemetry technology may be employed so that it in the event of theft a signal could be

sent to receiver 27 instructing the controller to disconnect power supply to the vehicle and/or making the vehicle inoperative.

A GPS/EPIRB unit 28 may also be connected to microprocessor 9 if required. Should motion detector 25 indicate that the vehicle has been involved in an accident the GPS/EPIRB unit 28 may be activated to send an emergency signal indicating the location of the controller. Should a vehicle be missing for an extended period of time a signal may be sent to receiver 27 via an RF link to actuate GBS/EPIRB unit 28.

As a further safety feature SCR 5 may be switched off if the temperature sensor 8a indicates that the environmental temperature in the engine bay is above a threshold level, perhaps due to fire.

For safety reasons certain types of battery discharge may be allowed where discharge would not otherwise be allowed. If the system detects that the hazard lights are on it may allow discharge past the MAL threshold and perhaps to LOS. Further, if the system detects that the headlights are on whilst the vehicle is moving (by a motion detector) but the alternator is not supplying power (perhaps the belt is broken and so no charging current is detected and demand on the battery increases) it may allow the battery to continue to discharge to LOS or below. Alternatively, where the controller detects that the vehicle is operating, the alternator has failed and the battery has been discharged to the MAL threshold, the driver may be warned by an audible signal from speaker 26 and/or a visual indication. If the system includes a user interface 15 the visual indication may be in the form of a flashing display or flashing light. Otherwise the controller may temporarily disconnect the battery supply for short intervals so as to flash the car headlights and/or cause perceptible vibration in the engine. A period after the alarm , power supply to the vehicle may be disconnected. Should an attempt be made to restart the

vehicle the battery will be reconnected so as to enable the vehicle to move out of the way of the hazard. A short period thereafter the alarm will sound again and the battery will be disconnected , although it may be reconnected if a user chooses to override this function. Alternatively, power supply to the vehicle may be slowly ramped down by pulse width modulating SCR 5 so that a user perceives a gradual reduction of power from the battery where in fact the battery has maintained sufficient charge to restart the engine but has simply gradually reduced the power supplied.

The battery may also include means to detect when batteries are connected in reverse polarity during jump starting or that a short circuit has occurred and switch off both SCRs immediately.

The system will preferably be mounted within a battery casing of standard dimensions having the standard two terminal configuration as shown in figure 3. Figures 3 to 5 show the physical construction of a battery incorporating a removable controller 31 of the form shown in figure 1. The components of controller 31 are as shown in figure 1, other than SCRs 5 and 6, which are externally located and are housed within a removable casing which may be inserted into battery 30 and removed therefrom. The electrical connections between controller 31 and battery 30 are by way of contact connections 7a to 7i, 8b to 8g and 9a and 9b (these correspond with the links shown in figure 1). Corresponding pads are provided on the base of casing 31 so as to connect the components by contact connections to the pins 7a to 7i, 8b to 8g and 9a and 9b shown in figure 5. SCRs 5 and 6 are provided external to casing 31 so that they may be mounted upon heat sink 32 to easily dissipate heat.

The controller unit 31 is removable from battery 30 so that if the battery deteriorates the controller 31 may simply be transferred to a new battery 30, avoiding the need to purchase a new controller and transferring the historical

data of the vehicle. When casing 31 is removed from battery 30 the controller senses that it has been removed as no cell voltages are sensed by ADC 7. If controller 31 is reinserted into the old battery it may assume that the battery has a proportion (say 80%) of its previously aged condition as the battery may have suffered deterioration in the interim due to improper treatment. If the battery performs according to its prior performance then the prior parameters may be reinstated. If the controller 31 is inserted within a new battery the controller will assume that the battery has the standard manufacturers default characteristics. However, the characteristics of the vehicle in which the battery is employed will be retained and can be used in combination with the standard battery characteristics. A servicemen can input details of the battery type via interface 15.

Referring now to figures 6 and 7 alternative constructions are shown. In figure 6 controller 36 is provided along a side of battery 35. In figure 7 controller 38 is provided at one end of battery 37.

Referring now to figure 2 a dual battery configuration is shown. It will be seen that the arrangement is the same as figure 1 except that a second battery 20 is provided having separate SCRs 21 and 22. Corresponding integers have been given the same numbers as in figure 1. The cells of battery 20 may be monitored by ADC 7 via lines 7i to 7o and temperature sensor 8 via lines 8i to 8n in a similar manner to the cells of battery 1. Battery 20 may be a cranking battery reserved for starting the engine and battery 1 may be a running battery. Thus SCRs 5 and 6 need only be able to handle low currents. Discharge SCR 22 is a high current SCR which is switched on during starting. SCR 22 could be replaced by a solenoid switch, although this would be bulky. This arrangement has the advantage that the reserve capacity required to crank the engine does not need to be calculated. The system simply has to control charging of the batteries and ensure they are not discharged below LOS. This

arrangement also has the advantage over three terminal batteries that battery 1 may be used for cranking if battery 20 is discharged.

In this configuration the controller can control the charging sequence and balance of the two battery sections to allow the cranking battery 20 to be charged at a higher rate or before the running battery 1 is fully charged. This ensures that the cranking battery 20 remains as fully charged as possible to enable starting even if a poorly tuned engine has drained the reserve capacity from the cranking battery 20 during prolonged starting. This arrangement allows the running battery 1 to have a LOS point well below that of the starting battery due to the construction of the running battery allowing deep cycle operation. The LOS point will, however, be kept just above the point at which damage to cell plates occurs.

In the event that the cranking battery section 20 fails, or when the LOS point is approaching, the running battery section 1 may be switched in as a replacement and /or support for cranking battery 20 to ensure starting.

Figure 8 shows an alternative embodiment in which all components of the controller, including the SCRs, are housed within unit 42. The controller unit 42 is connected to terminals 43 and 44 of a standard automobile battery 41. The electrical system of a vehicle is connected to terminals 45 and 46 of controller 42.

Figure 9 shows a block diagram of the controller 42 shown in figure 8. It will be seen that the controller corresponds substantially to the controller shown in figure 1 except that ADC 7 does not sense the voltages at lines 7c to 7h and temperature sensor 8 does not sense the temperature of each cell via sensors 8b to 8g. Accordingly, the controller cannot monitor the voltage across or temperature of each cell and so must monitor the general condition of battery

41 only. By monitoring the voltage across terminals 43 and 44 of battery 41 and the current flowing through load sensing means 3, charging and discharging of battery 41 can be calculated. As the temperature of the battery cells is not monitored any loss attributable to a particular cell cannot be identified and battery 41 is characterised generally.

It will be appreciated that the controller shown in figure 9 may be located remotely from the battery and may be incorporated within the electrical system of a vehicle. In such a case some loads may be directly connected to terminals 43 and 44 of battery 41 (i.e. the starter motor) whilst other loads are connected through terminals 45 and 46. This allows the size of discharge SCR 5 to be reduced. It will also be appreciated that when the controller is incorporated within an automobile electrical system the supply of power to different types of devices may be individually controlled via additional semiconductor switches and detailed status information may be displayed on a driver console. This enables certain loads to be disconnected when a predetermined battery capacity threshold is reached whilst other loads are still driven.

In such a system multiple thresholds above LOS (MALs) may be provided so that selected devices are not supplied with power when a particular MAL threshold is reached.

It will be appreciated that other suitable semiconductor switching devices, such as FETs, may be substituted for the SCRs shown in the examples.

It will thus be seen that the present invention provides a battery and battery controller
that enhances the serviceability and life expectancy of a battery whilst being directly substitutable for a standard two terminal battery.

Where in the foregoing description reference has been made to integers or components having known equivalents then those equivalents are hereby incorporated as if individually set forth.

Although this invention has been described by way of example it is to be appreciated that improvements and/or modifications may be made thereto without departing from the scope or spirit of the invention.

CLAIMS

1. A controller for controlling the discharge of a battery via terminals which are connected, in use, to an electrical load, wherein the controller controls the rate of discharge of the battery via the terminals in dependence upon the state of charge of the battery and the load connected to the terminals.

2. A controller as claimed in claim 1 including monitoring means for monitoring the charging and discharging of the battery to determine the state of charge of the battery.

3. A controller as claimed in claim 2 wherein the monitoring means monitors the voltage across the terminals and the current flowing through the controller.

4. A controller as claimed in any one of the preceding claims wherein the controller reduces the rate of discharge of the battery when the state of charge of the battery falls below a charge threshold.

5. A controller as claimed in claim 4 wherein the controller reduces the rate of discharge of the battery to a low level when the state of charge of the battery reaches the charge threshold value.

6. A controller as claimed in any one of the preceding claims wherein the controller reduces the rate of discharge of the battery when a specified type of load has been discharging the battery for a specified period under specified conditions.

7. A controller as claimed in claim 6 suitable for installation in a vehicle wherein the rate of discharge of the battery is reduced after a specified type of load has been discharging the battery for a predetermined time when the controller detects that the engine of the vehicle is not running.

8. A controller as claimed in any one of claims 4 to 7 wherein the controller periodically connects the terminals of the battery to the output terminals after the rate of discharge of the battery has been reduced and increases the rate of discharge of the battery when the monitoring means detects that a predetermined load type has been connected to the terminals.

9. A controller as claimed in claim 8 wherein, after the rate of discharge has been reduced, the rate of discharge of the battery is increased when the monitoring means detects that a load indicative of a vehicle starting load is connected to the output terminals.

10. A controller as claimed in any one of claims 4 to 9 wherein the charge threshold value is based upon measurements made by the controller in use as to the charge required to start an engine of a vehicle in which the battery is installed.

11. A controller as claimed in claim 10 wherein the charge threshold value is a margin above the minimum charge required to start the vehicle.

12. A controller as claimed in any of claims 4 to 11 wherein the controller includes a real time clock and the controller calculates the reserve capacity of the battery based upon historical charge and discharge characteristics of the battery.

13. A controller as claimed in any one of claims 4 to 12 wherein the controller may be controlled by a user to increase the discharge rate of a battery after the discharge rate of the battery has been reduced by the controller.

14. A controller as claimed in claim 13 wherein the user control is by switching on and off of a starter switch of a vehicle electrical system connected to the terminals.

15. A controller as claimed in any one of claims 4 to 14 wherein the rate of discharge of the battery is gradually stepped down over time when the state of charge of the battery falls below a charge threshold value.

16. A controller as claimed in any one of claims 4 to 15 wherein an alarm signal is generated when the state of charge of the battery falls below the charge threshold value.

17. A controller as claimed in any one of the preceding claims wherein the controller allows charging currents to flow to the battery when the voltage across the terminals indicates that a charger is connected thereto and the battery is below its full state of charge.

18. A controller as claimed in any one of the preceding claims wherein the controller monitors and stores the sequence of loads connected to the output terminals during a normal start up and reduces the rate of discharge of the battery if, during start up, the normal load sequence is not followed.

19. A controller as claimed in claim 18 wherein the normal sequence is for a door light load, a solenoid load and a starter motor load to follow in succession.

20. A controller as claimed in claim 18 or claim 19 wherein the rate of discharge of the battery is reduced by the controller to such a level that an automobile cannot be started.

21. A controller as claimed in any one of the preceding claims wherein the controller incorporates a movement detector which is activated when the controller is exposed to a severe shock, which causes the controller to reduce the rate of discharge of the battery.

22. A controller as claimed in any one of the preceding claims wherein the controller includes a movement detector which indicates whether the battery is exposed to minor shock forces experienced during the operation of a vehicle.

23. A controller as claimed in any one of the preceding claims wherein the controller includes a movement detector which is activated when movements indicative of vehicle tampering are experienced by the controller and wherein the controller reduces the rate of discharge of the battery upon detecting the activation of the movement detector.

24. A controller as claimed in any one of the preceding claims wherein the battery supplies an output voltage greater than is required to supply an electrical system connected to the output terminals and the controller modulates the supply of power from the battery to the terminals to achieve a desired power output.

25. A controller as claimed in any one of the preceding claims wherein the battery is suitable to supply power both for starting an engine of a vehicle and for supplying the other electrical loads of a vehicle.

26. A controller as claimed in any one of the preceding claims having only two terminals for connection to the electrical system of a vehicle.

27. A controller as claimed in any one of the preceding claims incorporating an RF receiver which, when activated, causes the controller to reduce the rate of discharge of the battery.

28. A controller as claimed in any one of the preceding claims incorporating a GPS/EPIRB system which transmits the location of the controller, as determined by the GPS, via an EPIRB when activated.

29. A controller as claimed in claim 28 when dependent upon claim 27 wherein the EPIRB is activated by the controller when it receives a predetermined signal from the RF receiver.

30. A controller as claimed in any one of the preceding claims wherein the controller includes one or more semi-conductor switch to control the discharge of the battery via the terminals.

31. A battery unit as claimed in any one of the preceding claims wherein the controller includes one or more semiconductor switch to control the flow of current from the terminals to the battery during charging.

32. A battery unit as claimed in claim 30 or claim 31 wherein the semiconductor switches are SCRs or FETs.

33. A battery unit as claimed in any one of the preceding claims including a display means for displaying the condition of the battery.

34. A battery unit as claimed in claim 33 wherein the display means is a series of LEDs.

35. A controller as claimed in any one of the preceding claims wherein the controller is contained within a housing adapted to be secured to and electrically connected to the terminals of a battery.

36. A battery unit incorporating a controller as claimed in any one of claims 1 to 34 and a battery.

37. A battery unit as claimed in claim 35 having external dimensions substantially the same as a standard automotive battery.

38. A battery unit as claimed in claim 36 or claim 37 wherein the controller is a removable unit that can be removed from a battery unit and inserted in another battery unit.

39. A controller as claimed in any one of claims 36 to 38 wherein the monitoring means monitors the temperature of the battery.

40. A controller as claimed in claim 39 wherein the voltage across each cell of the battery is monitored by the monitoring means.

41. A controller as claimed in claim 40 wherein the temperature of each cell of the battery is monitored by the monitoring means.

42. A controller as claimed claim 39 wherein the controller reduces the rate of discharge of the battery when the temperature of the battery exceeds a predetermined level.

43. A battery unit as claimed in any one of claims 39 to 41 when dependent upon claim 12 wherein the reserve capacity of the battery is calculated having regard to battery temperature over time.

44. A battery as claimed in any one of claims 39 to 41 wherein the condition of each cell of the battery is determined having regard to the voltage across each cell and the temperature of each cell over time.

45. A battery unit having first and second terminals, first and second batteries and a controller for selectively connecting the terminals of the first and second batteries to the first and second terminals.

46. A battery unit as claimed in claim 45 wherein the controller includes means for monitoring the load connected to the output terminals and connects the first battery to the output terminals when a load indicative of engine cranking is detected and connects the second battery when other electrical loads are detected.

47. A battery unit as claimed in claim 46 wherein the second battery is connected to the output terminals when a cranking load is detected and the state of charge of the first battery is below a threshold level.

48. A battery unit as claimed in claim 46 or claim 47 wherein the second battery is connected to the output terminals when a cranking load is detected and the first battery fails.

49. A battery unit as claimed in any one of claims 45 to 48 wherein the rate of discharge of the second battery is reduced when the state of charge of the second battery falls below a threshold level.

50. A battery unit as claimed in claim 49 wherein the first battery is connected to the output terminals to supply a non-cranking load when the state of charge of the second battery falls below a threshold level and a state of charge of the first battery is above a minimum level required to start an engine of a vehicle.

51. A battery unit as claimed in any one of claims 45 to 50 wherein the controller includes monitoring means for monitoring the output voltage and current flow of the battery unit.

52. A battery unit as claimed in any one claims 45 to 51 wherein the monitoring means monitors the temperature of the battery unit.

53. A battery unit as claimed in claim 51 wherein the monitoring means monitors the voltage of each cell of either or both the first and second batteries.

54. A battery unit as claimed in any one of claims 51 to 53 wherein the monitoring means monitors each cell of either or both the first and second batteries.

55. A battery unit as claimed in any one of claims 45 to 54 wherein the controller includes semi-conductor devices controlled by the controller to selectively connect a terminal of the first and second batteries to one of the terminals of the controller.

56. A battery unit as claimed in any one of claims 45 to 55 wherein the controller controls the flow of current from the terminals of the controller to the first and second batteries to control the rates of charging of the first and second batteries.

57. A battery unit as claimed in claim 56 wherein the first battery is charged at a higher rate than the second battery when the first battery requires charging.

58. A battery unit as claimed in claim 56 or claim 57 wherein semiconductive devices controlled by the controller selectively connect a terminal of the first and second batteries to a terminal of the controller.

59. An integrated battery and controller having only two terminals wherein the controller controls the rate of discharge of the battery via the terminals.

60. A controller for controlling the supply of power from a battery to an electrical system of a vehicle wherein the controller monitors the loads connected to the controller over time and stores a profile of loads connected to the controller and wherein the controller supplies power from the battery to the vehicle electrical system in dependence upon the loads connected to the controller.

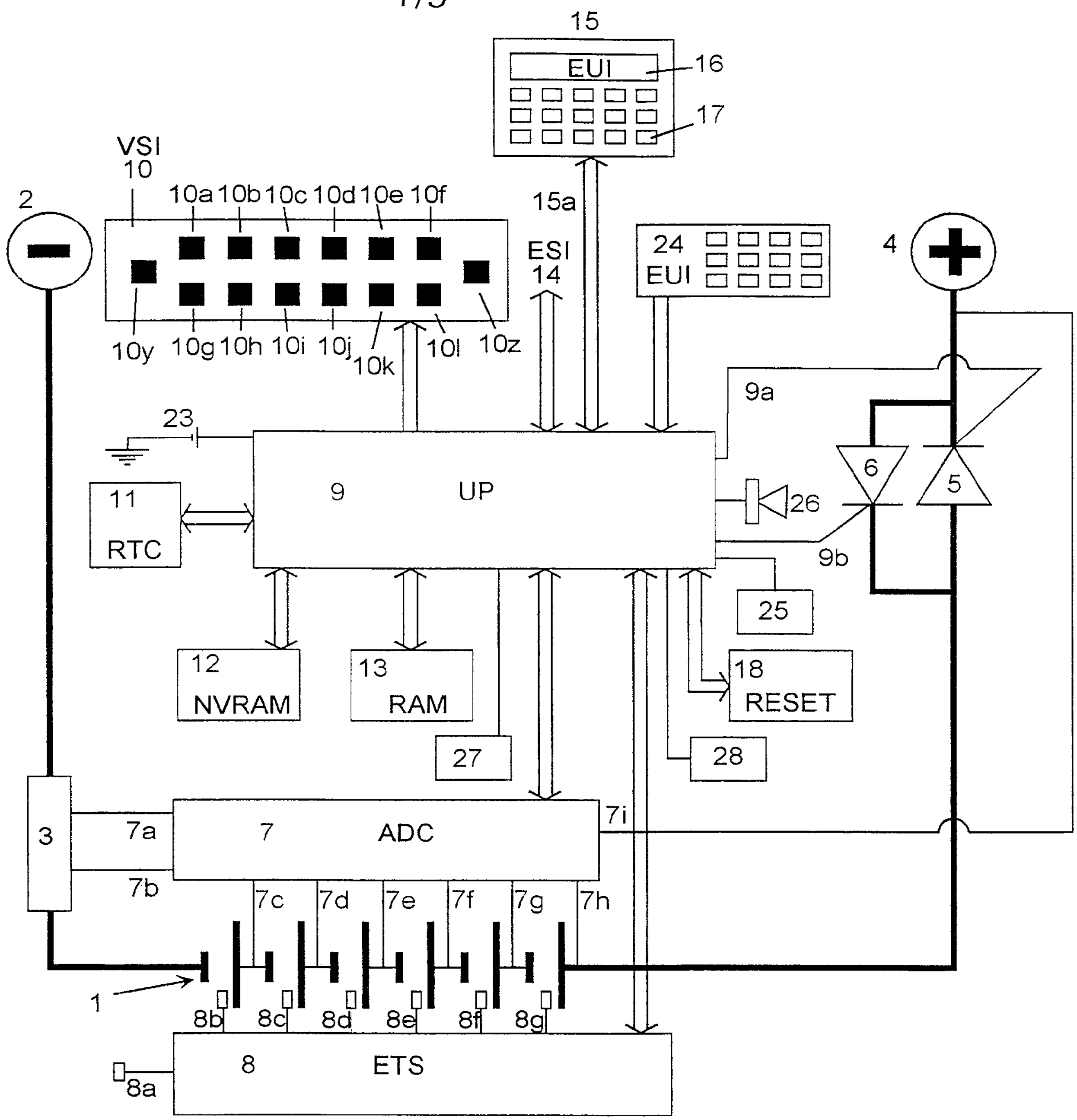
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Figure 1

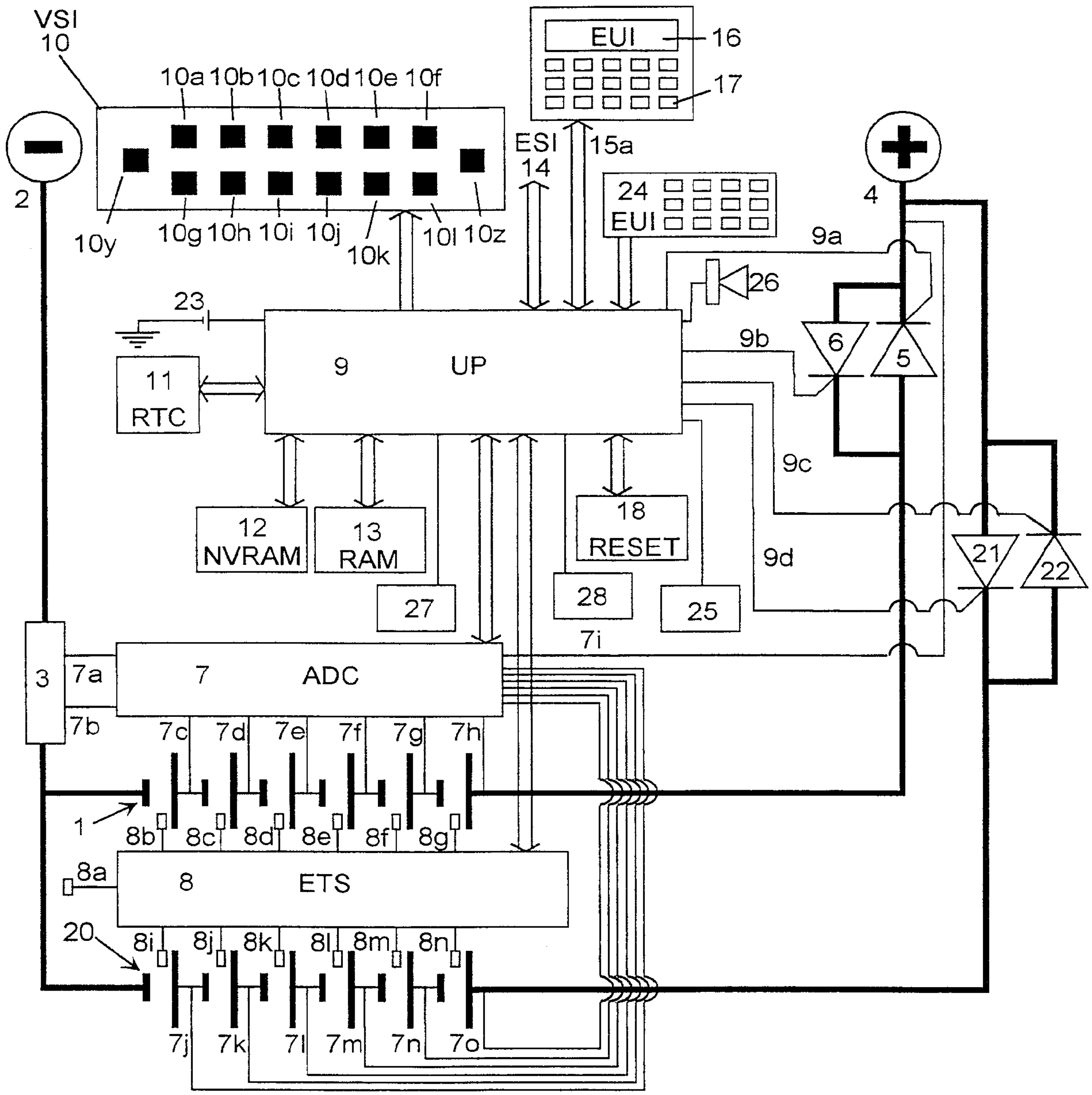
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Figure 2

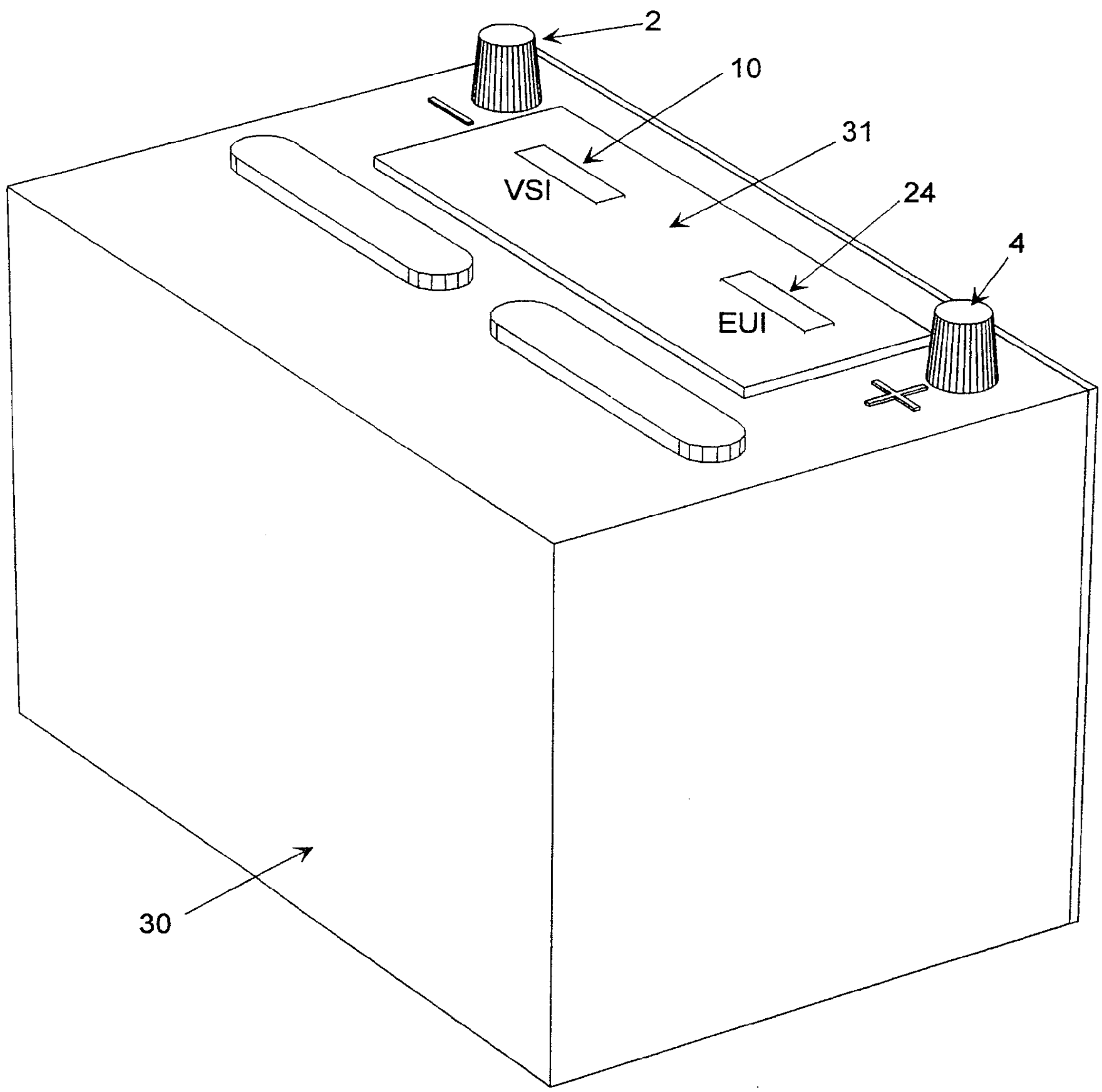


Figure 3

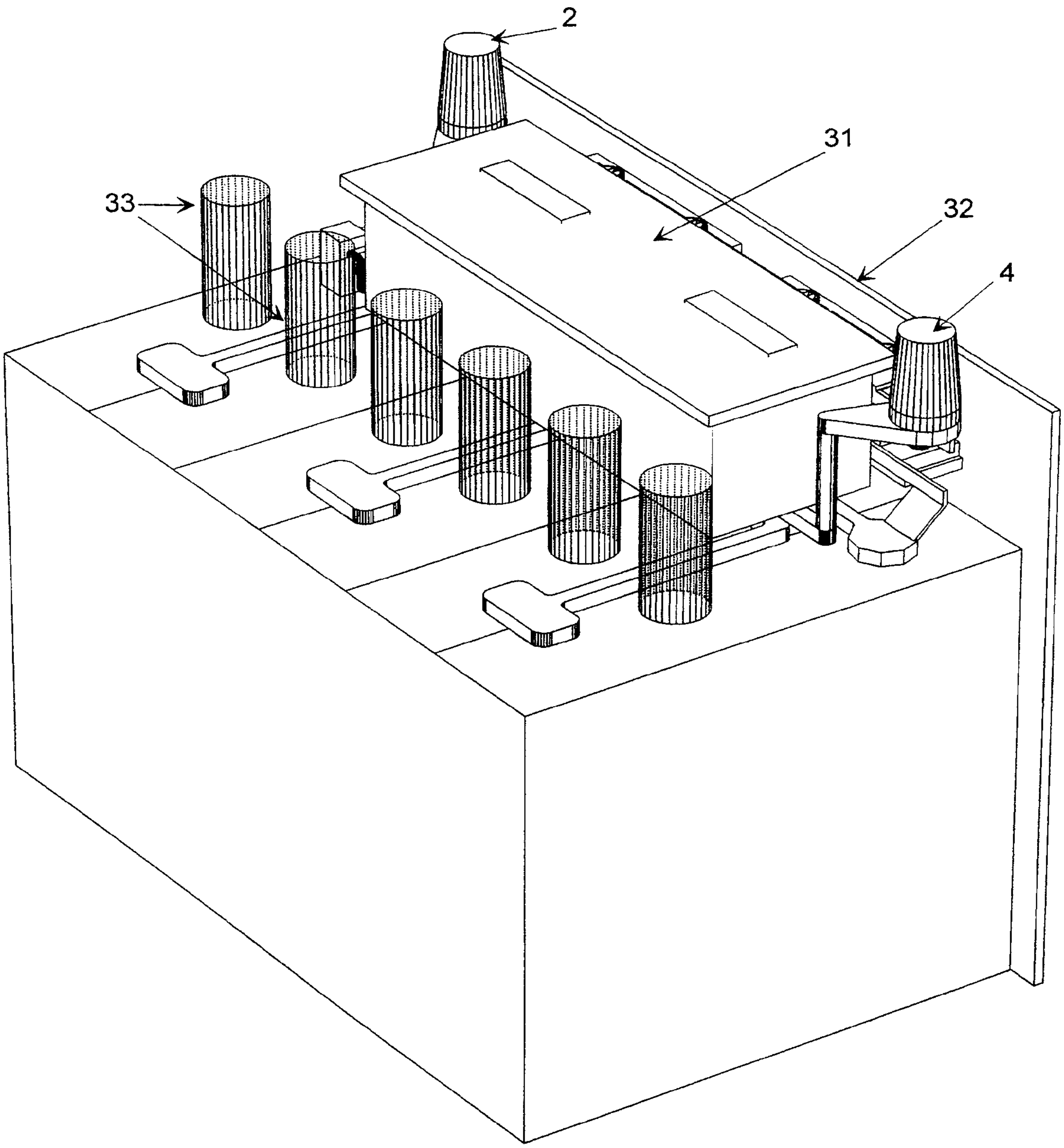


Figure 4

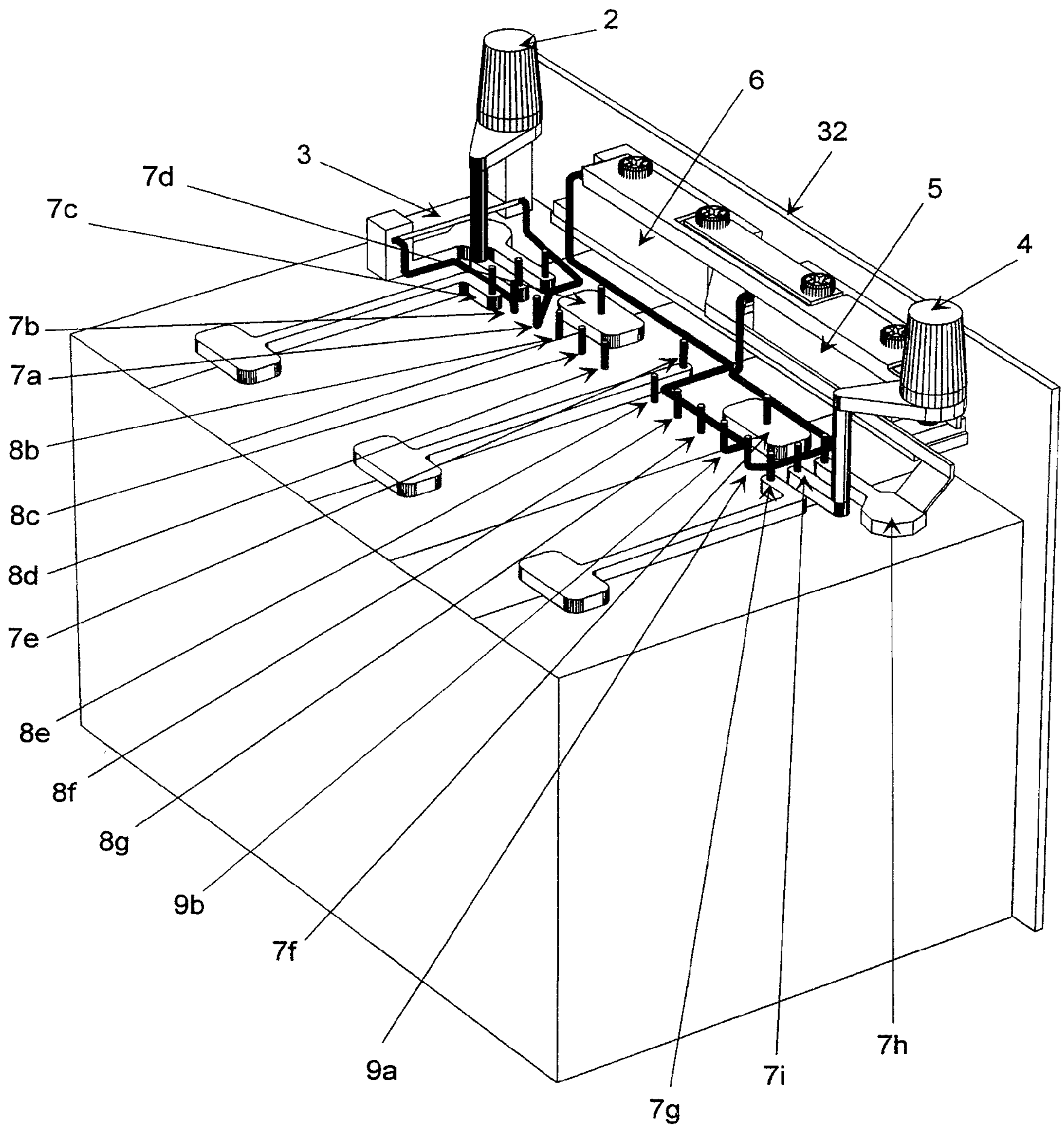


Figure 5

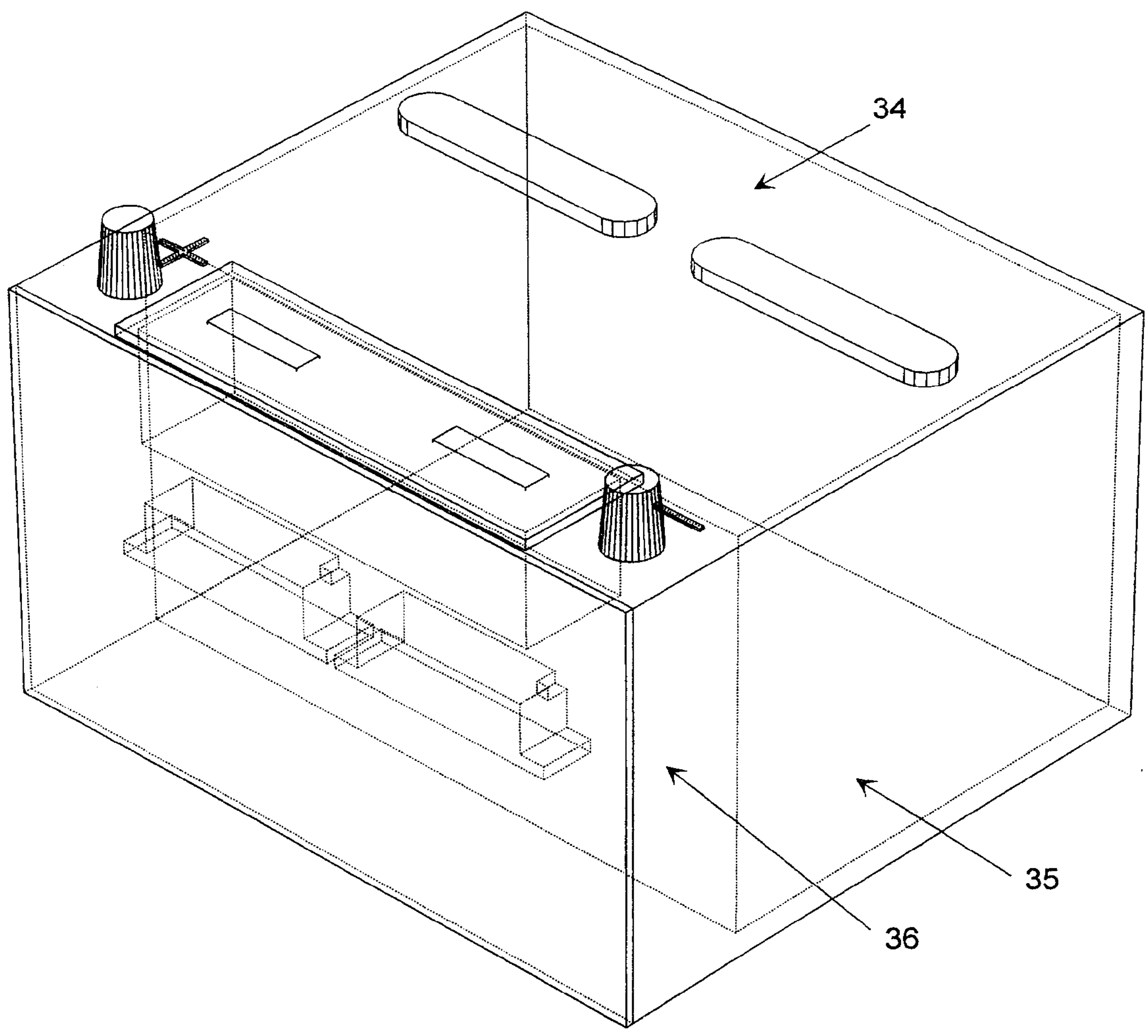


Figure 6

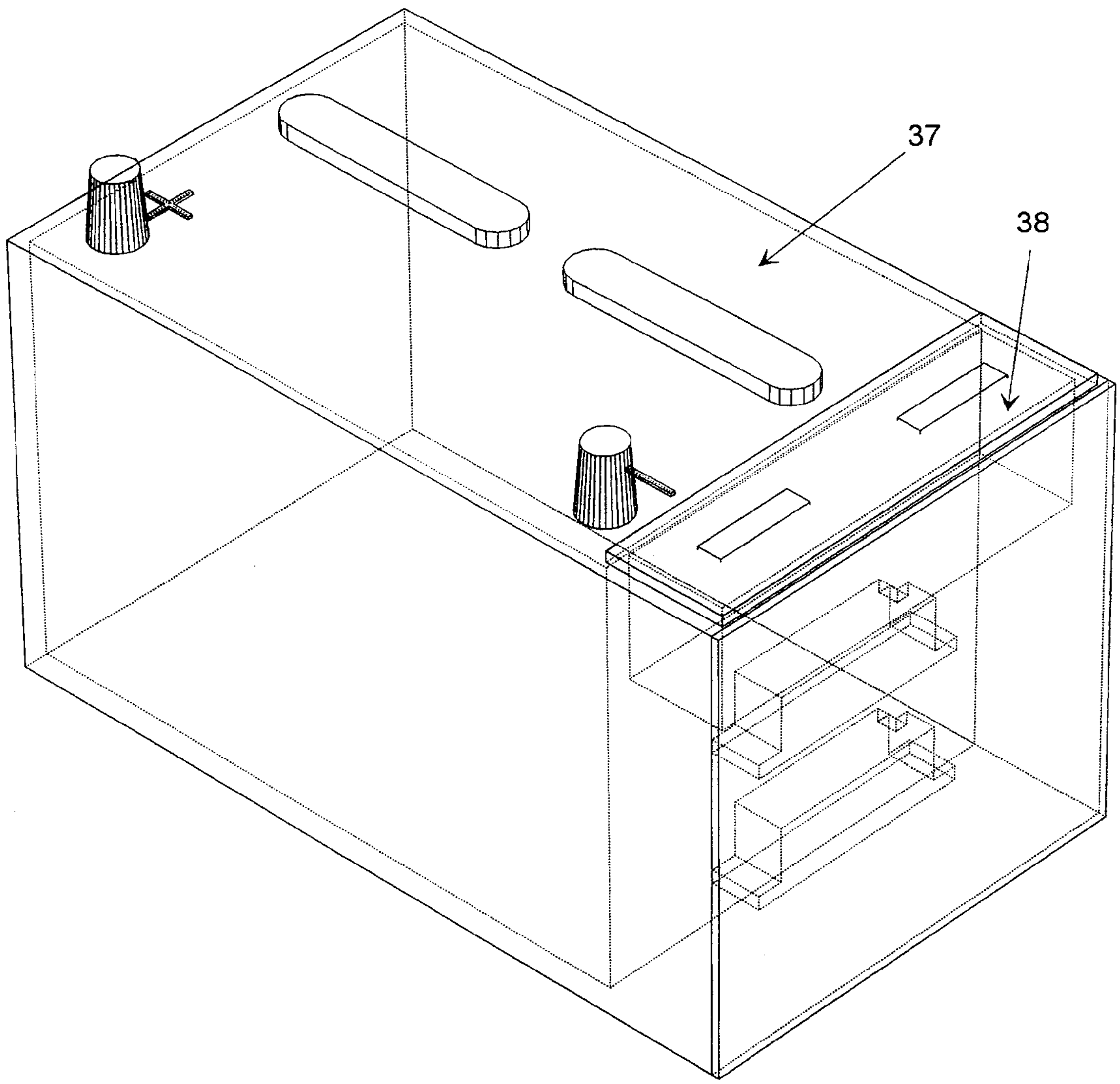


Figure 7

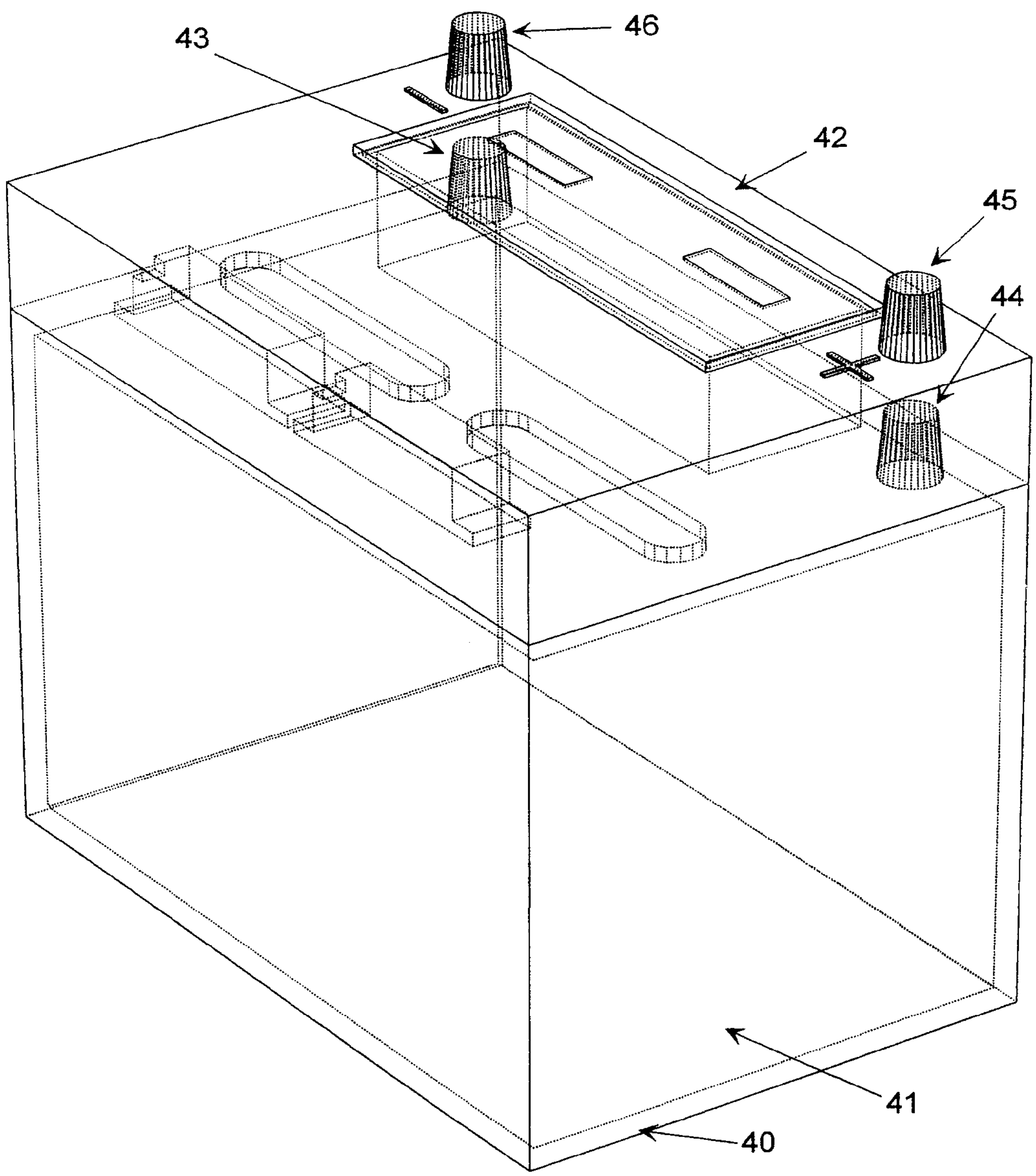
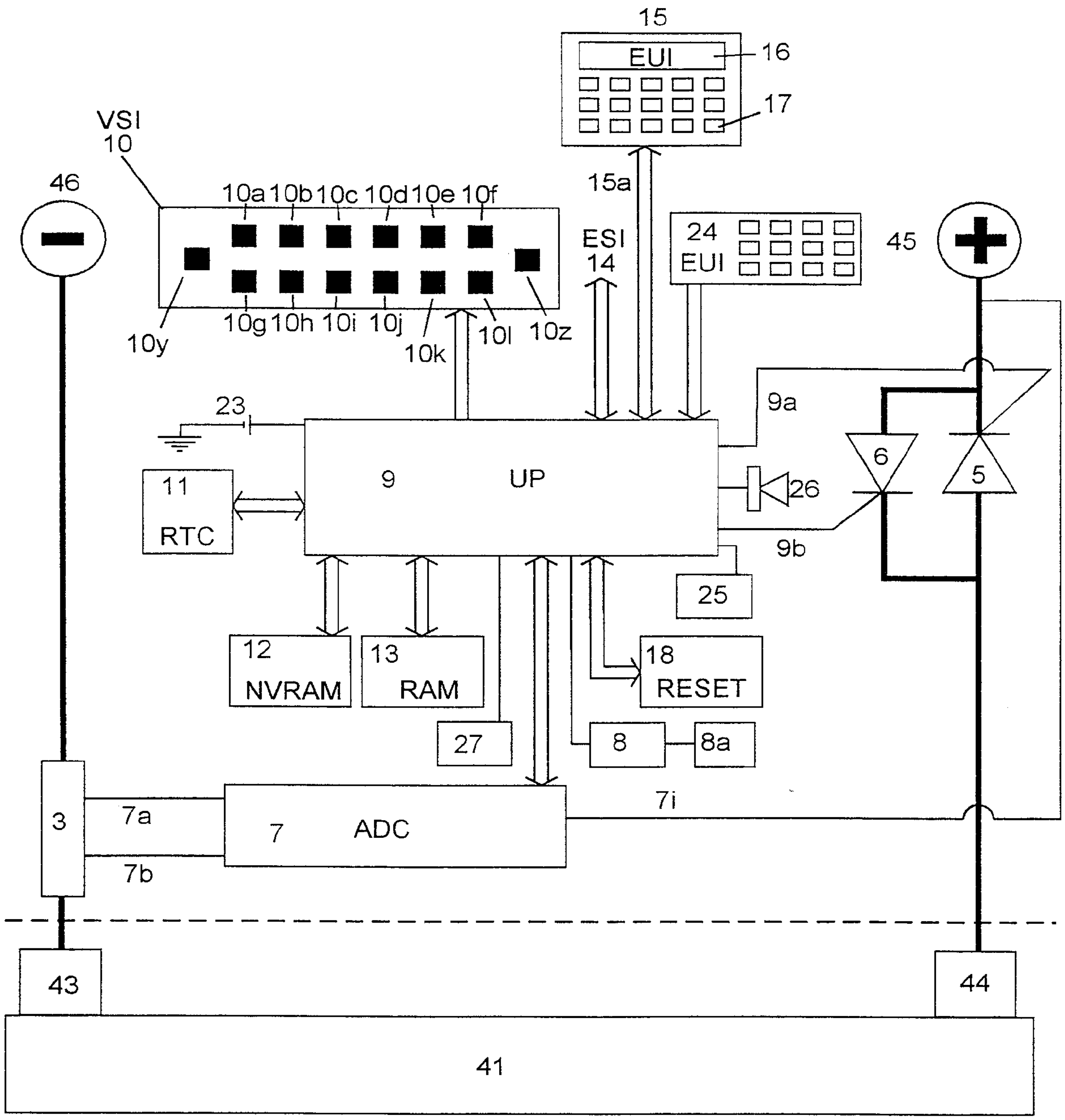


Figure 8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9a
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RTC
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8a
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ADC
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7b
43
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41

Figure 9

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/NZ 98/00069

A.	**CLASSIFICATION OF SUBJECT MATTER**
Int Cl^{6}:	H02H 7/18; H02J 7/34

According to International Patent Classification (IPC) or to both national classification and IPC

B.	**FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC: H02H 7/18; H02J 7/00, 7/34

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPAT :) (Control: or limit:) and (discharge) and (batter:)
JAPIO :)
IBM Patent Server: Battery, and load and charge

C.	**DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5343137 A (KITAOKA, FURUSE, TAKESUE, ITO) 30 August 1994	1 to 6,10,11,16,25,26,30, 32,36 to 44
X	US 5159257 A (OKA, HATANO) 27 October 1992	1 to 7
A	US 5332958 A (SLOAN) 26 July 1994	All
A	US 4902956 A (SLOAN) 20 February 1990	All

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 August 1998	03 SEP 1998

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INTERNATIONAL SEARCH REPORT

International Application No.
PCT/NZ 98/00069

C (Continuation) **DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4832146 A (LUBY) 23 May 1989	18 to 29
X	EP 583630 A (GLOBE UNION INC) 23 February 1994	45 to 58
X	US 5204610 A (GLOBE UNION INC) 20 April 1993	45 to 58
A	EP 372819 A (NIEHOFF CE & CO) 13 June 1990	45 to 58
A	GB 1473798 A (NISSAN MOTOR COMPANY LTD) 18 May 1977	45 to 58

Box 1 **Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)**

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box II **Observations where unity of invention is lacking (Continuation of item 2 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

The invention as defined in claim 1 is a controller for controlling the discharge of a battery. This controller is operated in dependence upon both the state of charge of the battery and the load. The terminology at claim 45 "a controller for selectively connecting" is much broader in scope and is considered as defining a multiple invention. Similarly, claims 59 and 60 did not define the features of dependency upon both the state of charge and the load.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims
2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International Application No.
PCT/NZ 98/00069

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	5343137	JP	5205781				
US	5159257	JP	3248941				
US	5332958	US	4902956	US	5089762	AT	120896
		AU	46683/89	CA	2003233	DE	68922099
		EP	407525	JP	4505244	WO	90/06614
US	4902956	US	5089762	US	5332958	AT	120896
		AU	46683/89	CA	2003233	DE	68922099
		EP	407525	JP	4505244	WO	90/06614
US	4832146	NONE					
US	5204610	NONE					
EP	583630	JP	6299937	MX	9304398	US	5316868
EP	372819	AT	133013	AU	45793/89	CA	1317634
		DE	68925409	ES	2081854	GR	3018654
		JP	2197222	TR	24395	US	4963813
GB	1473798	JP	50153227	US	4056764		

END OF ANNEX